

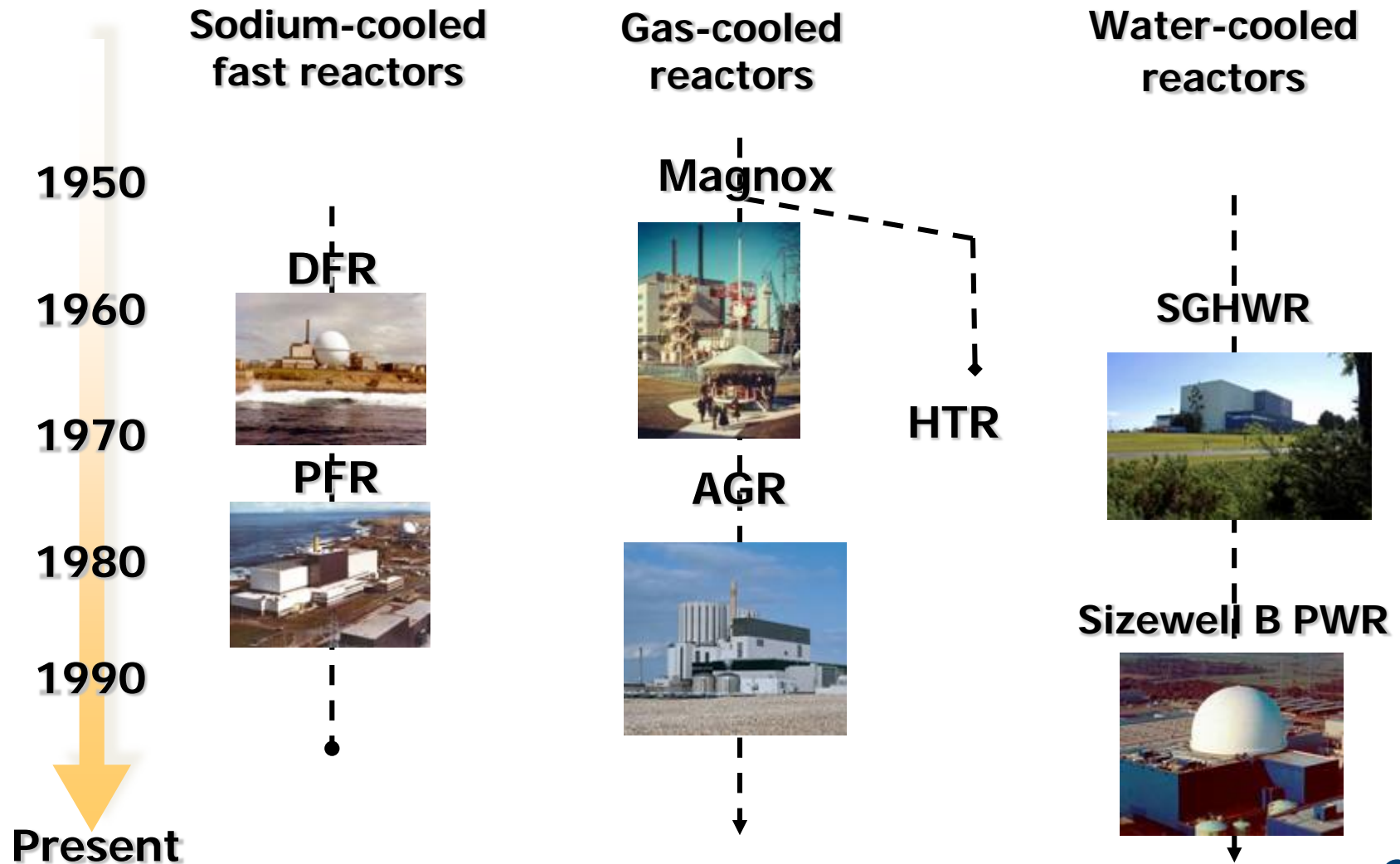
# Potential of Small Modular Reactors

Energiforsk 2017

January 2017

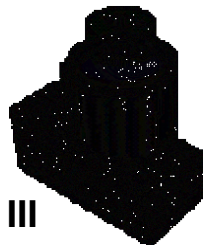
Dr Fiona Rayment  
Director Fuel Cycle Solutions

# UK Experience of Different Reactor Systems

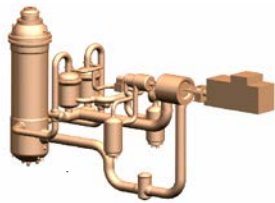


# UK Experience: Advanced Reactor Systems

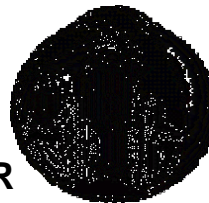
- Experience with advanced fast and thermal reactors:
  - Gen III, III+, IV
  - Fast Reactors
  - HTGRs
  - SMRs
  - Molten Salt Reactors
  - Th fuelled based systems
- History of participation in international projects
  - European Fast Reactor development
  - Numerous European Framework 5, 6 & 7 projects
  - South African PBMR project
  - Generation-IV VHTR, SFR, and GFR systems



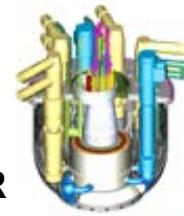
Gen III



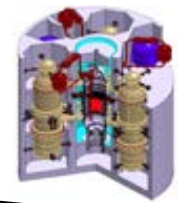
HTR



SMR



SFR



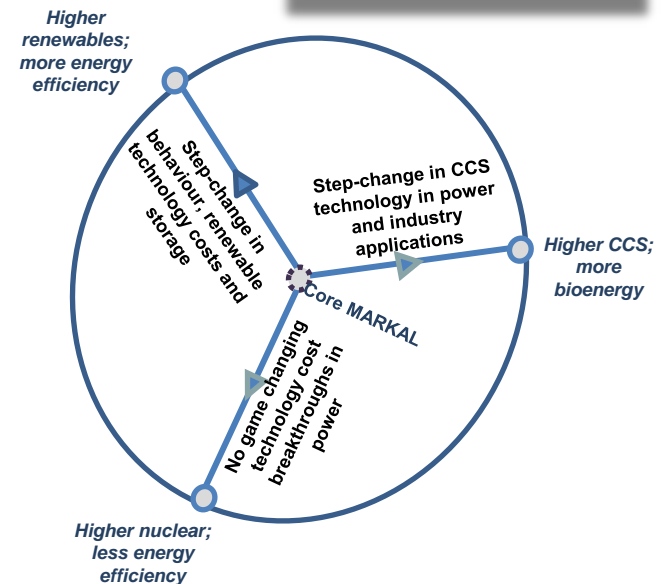
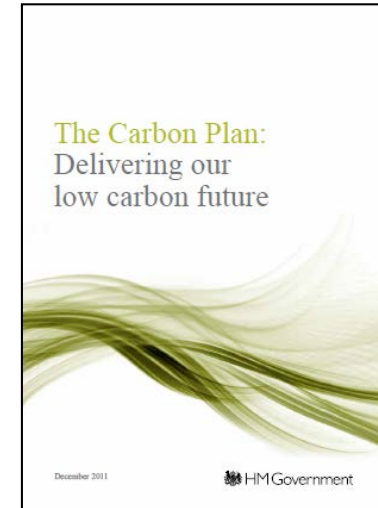
GFR

Present

2050 ?

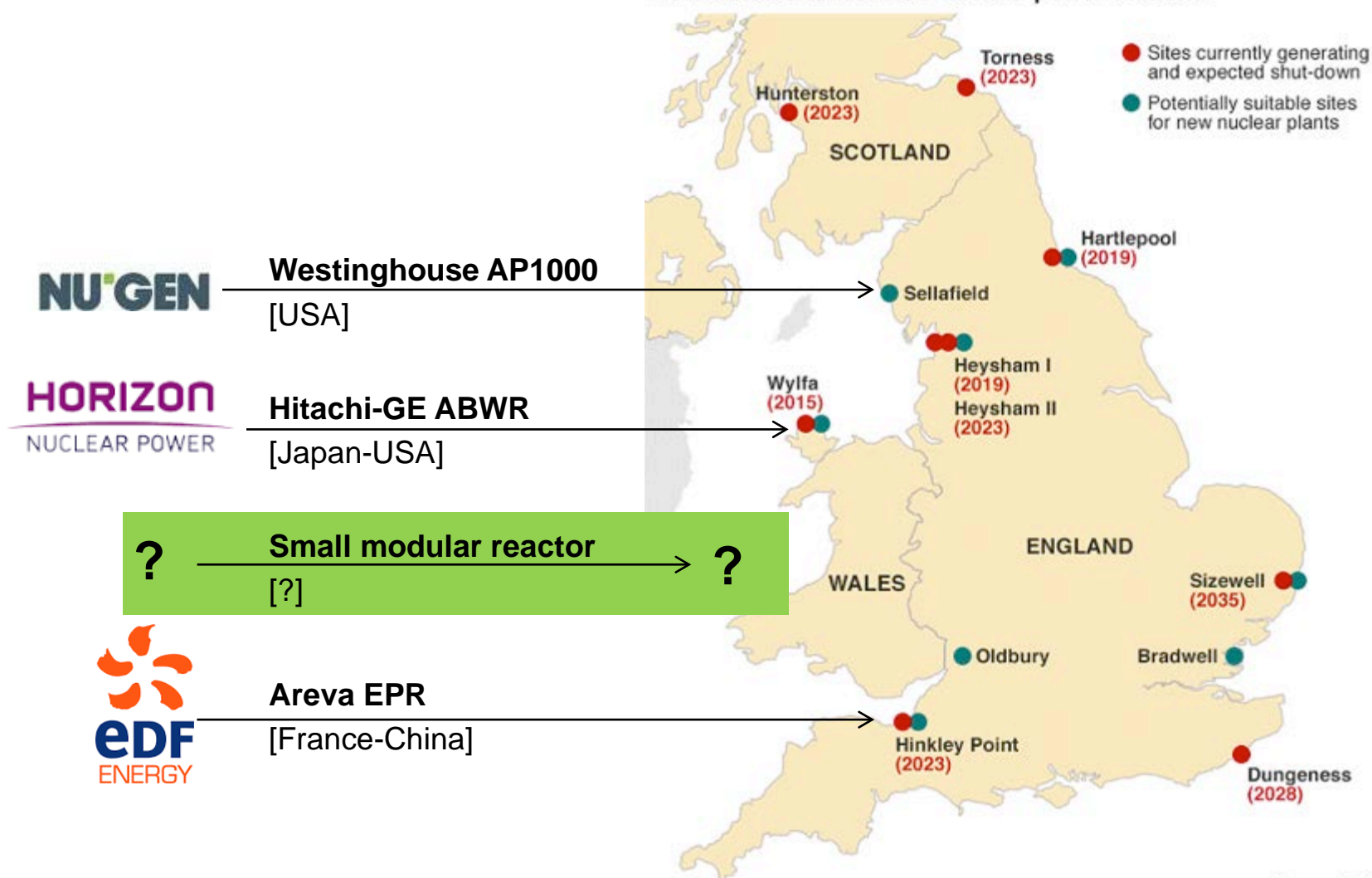
# The Carbon Plan: Sustainable Energy

- Legally binding 80% emission reduction by 2050
- Low carbon generation needed for:
  - Electricity
  - All transportation
  - Domestic and Industrial Heat, Light & Power
- Electricity grid grows from ~85 GWe to ~300GWe
- Generation sources Renewables, CCS and Nuclear



# New Nuclear Build

Nominated sites for new nuclear power stations



# UK Nuclear Energy R&D

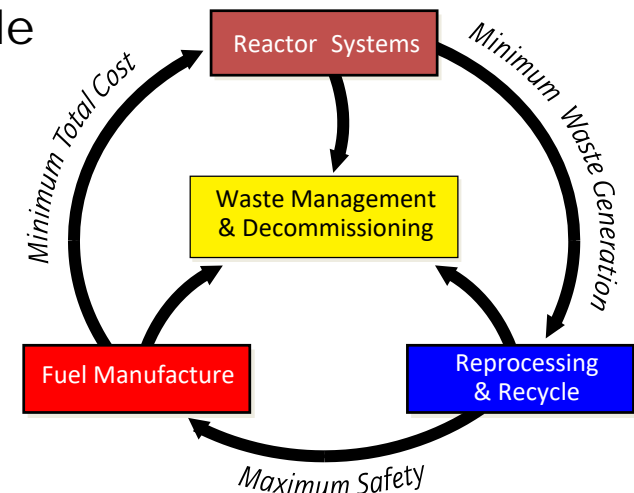
- Government recently announced a 5-year, £250M programme of nuclear R&D
- The UK's Nuclear Innovation & Research Advisory Board (NIRAB) recommended research in 5 main areas to;
  - Build on UK skills, experience and facilities
  - Maintain a balance across the whole fuel cycle
  - Establish international co-operations

## Programmes

1. Making the fuels of the future
2. 21<sup>st</sup> century manufacturing
3. Next generation reactor design
4. Advanced spent fuel recycling
5. Strategic toolkit



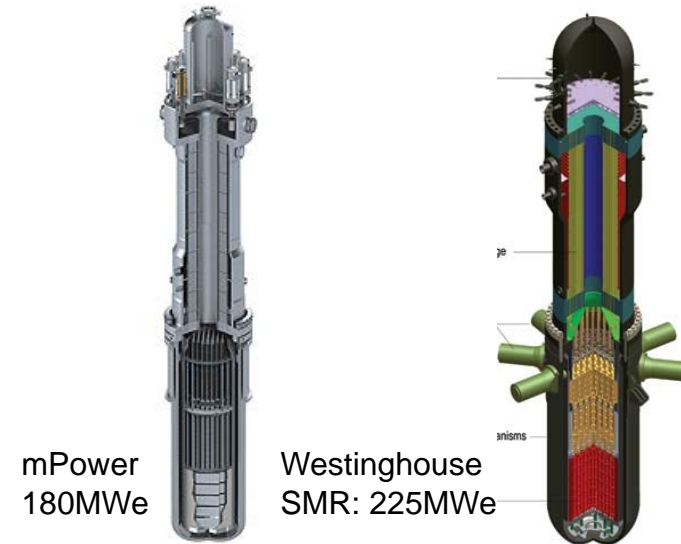
Department for  
Business, Energy  
& Industrial Strategy



# SMRs – Critical Characteristics

Compared with large nuclear stations  
EPR 1,600Gwe:

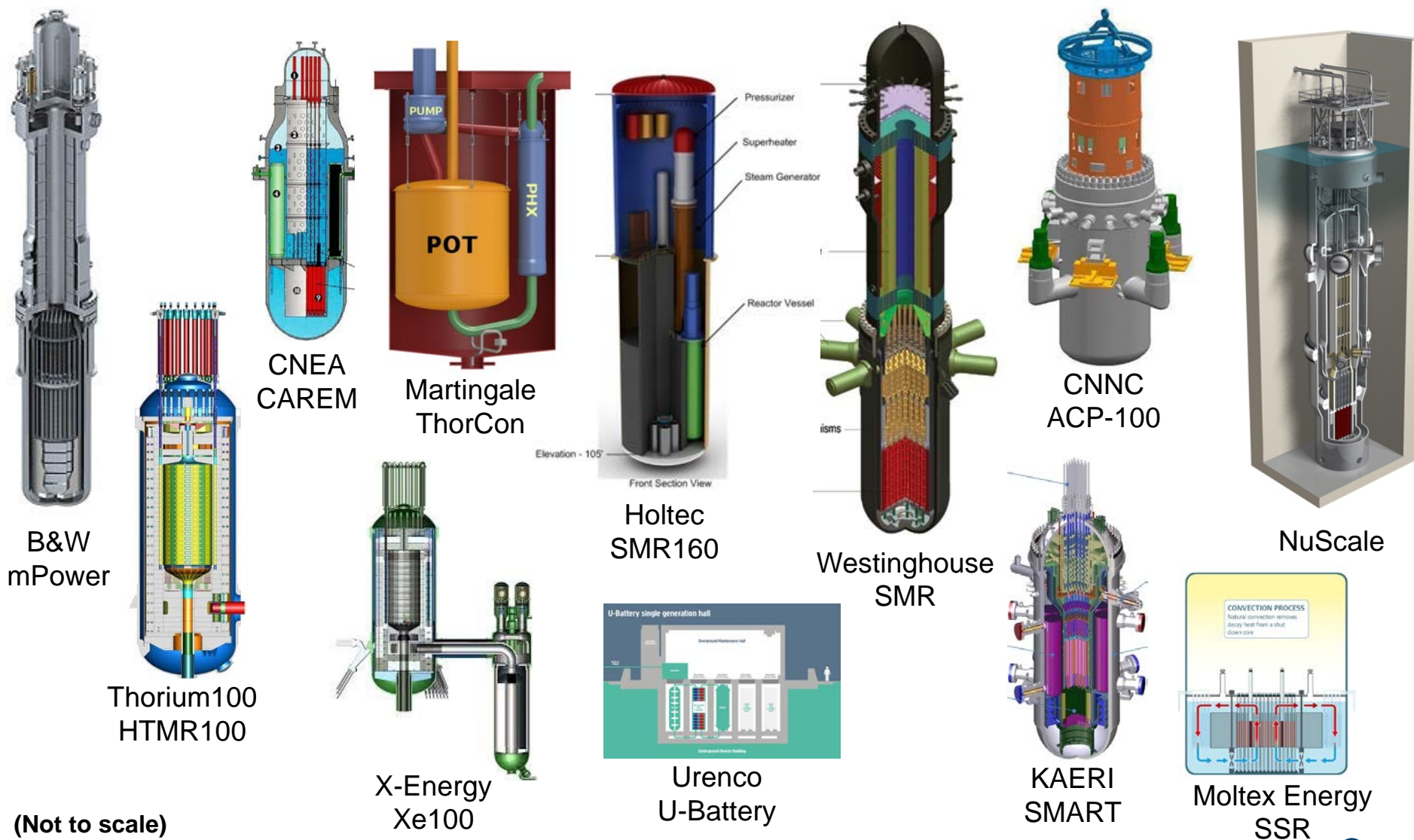
- Lower generating capacity  
    < 300 - 500MWe
- Simpler in design  
    Fewer pipes and welds
- Less on-site construction  
    Modular built in factories
- Faster construction times  
    ~ 3 years
- Greater flexibility  
    Load-following with renewables  
    Dual use including district heating  
    More potential sites



Oldbury Magnox: 2 x 220MWe



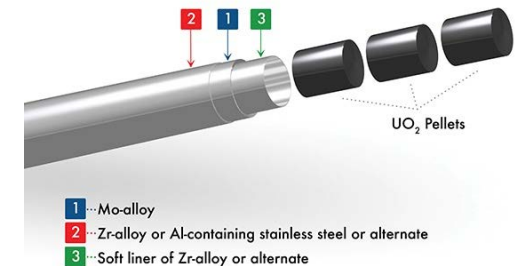
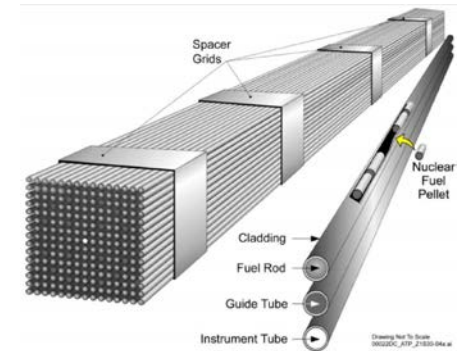
# Range of SMR designs



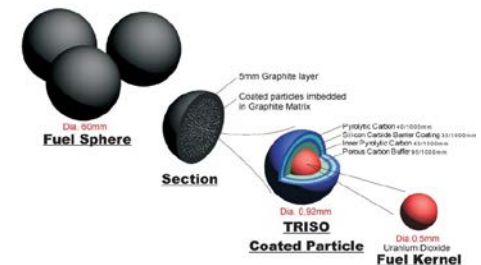


# ...And a range of fuel cycle options

- Fuel type:
  - iPWR: standard PWR fuel (shorter length)
  - HTR: fuel pellets (Triso)
  - MSR: fuel and coolant together
- Accident tolerant fuel development
- Enrichment
  - iPWR: < 5%
  - HTR: > 10%
  - MSR: < 5%
- Uranium supply expected to be stable
- Waste management
  - Modest increase in waste volume per MWh
- Potential fuel supply from UK
  - Urenco (enrichment)
  - Springfields Fuels Ltd (manufacture)

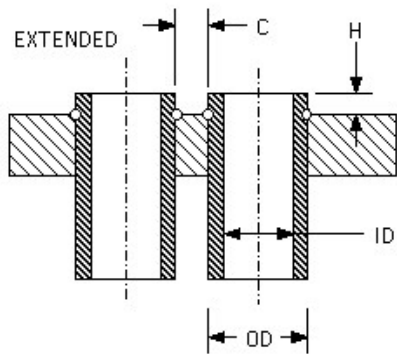


FUEL ELEMENT DESIGN FOR PBMR

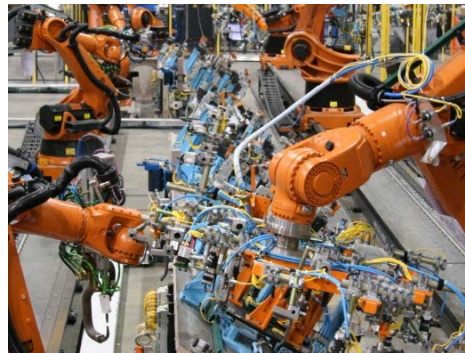


# SMRs in the UK – Why? Economic Driver

**Economic driver: opportunity for UK content and IP**



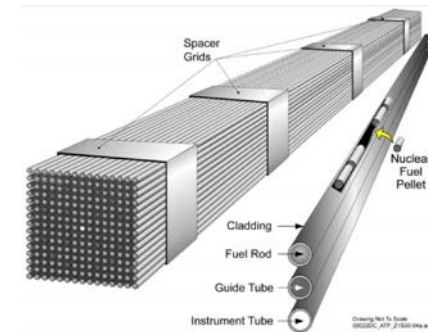
Detailed design



Manufacture



Construction



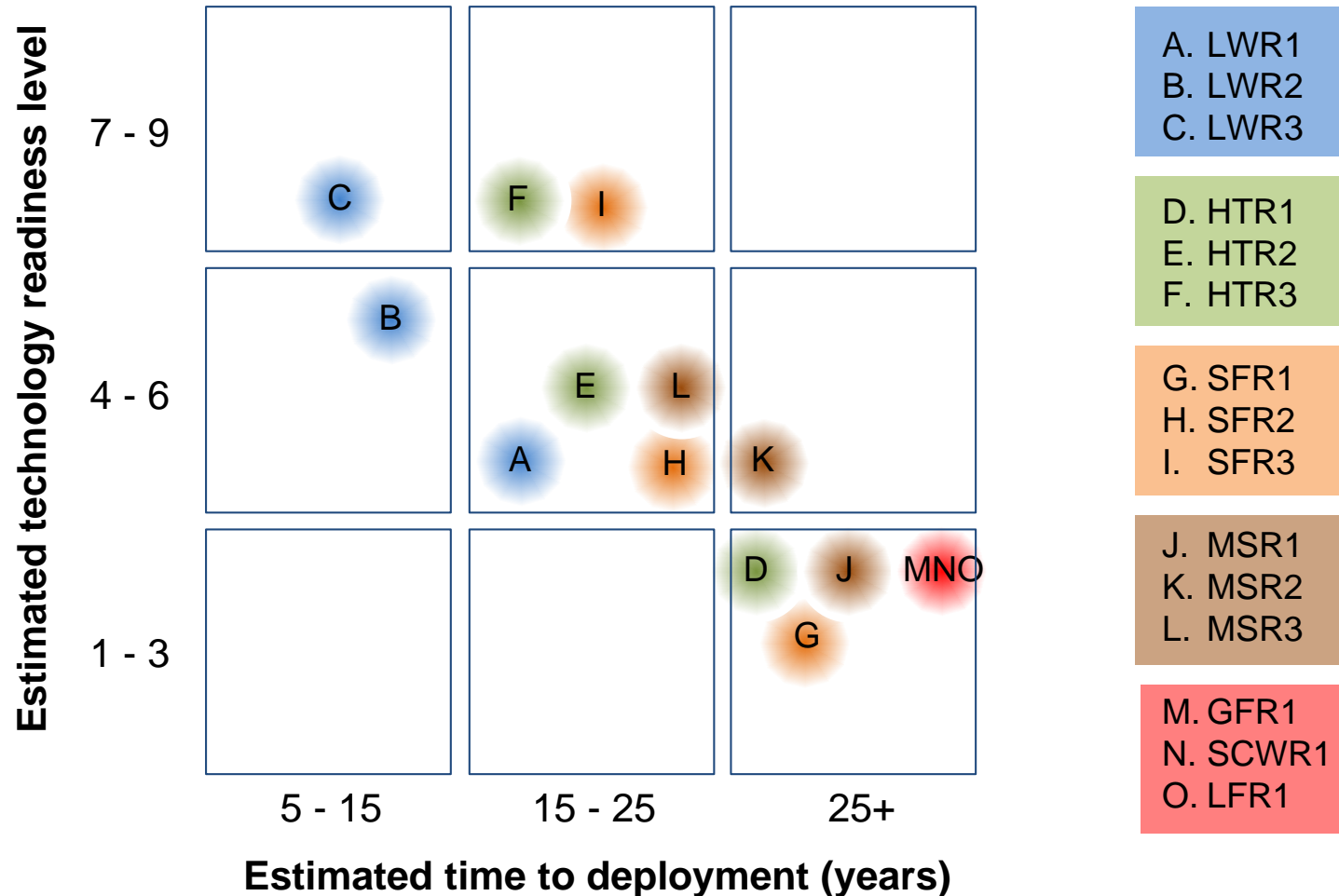
Nuclear fuel

Design for Manufacturing and Assembly (DfMA)

# SMRs in the UK – Why?

## Economic Driver

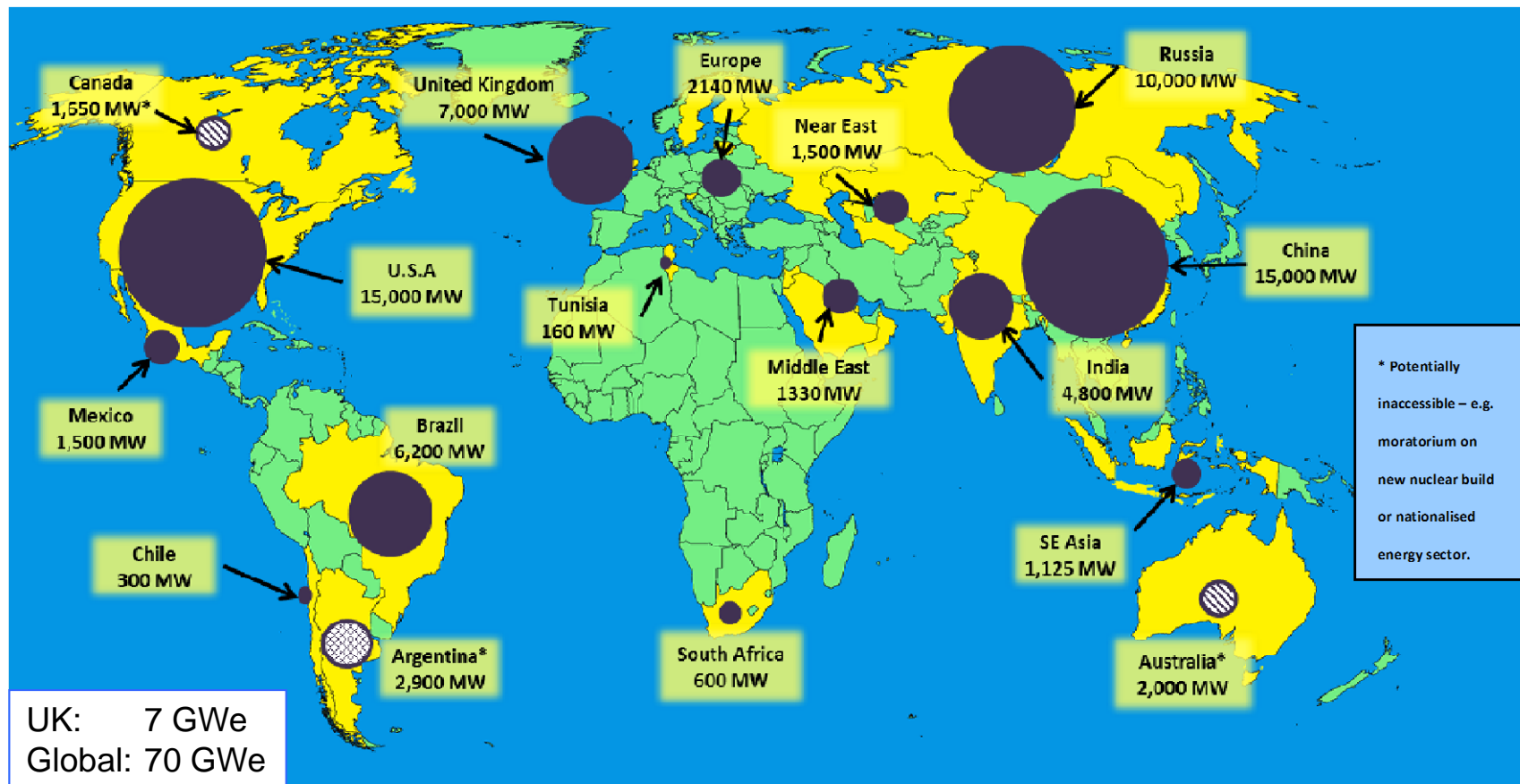
**Economic driver: opportunity for UK content and IP**



# SMRs in the UK – Why?

## Economic Driver

### Economic driver: international export opportunities

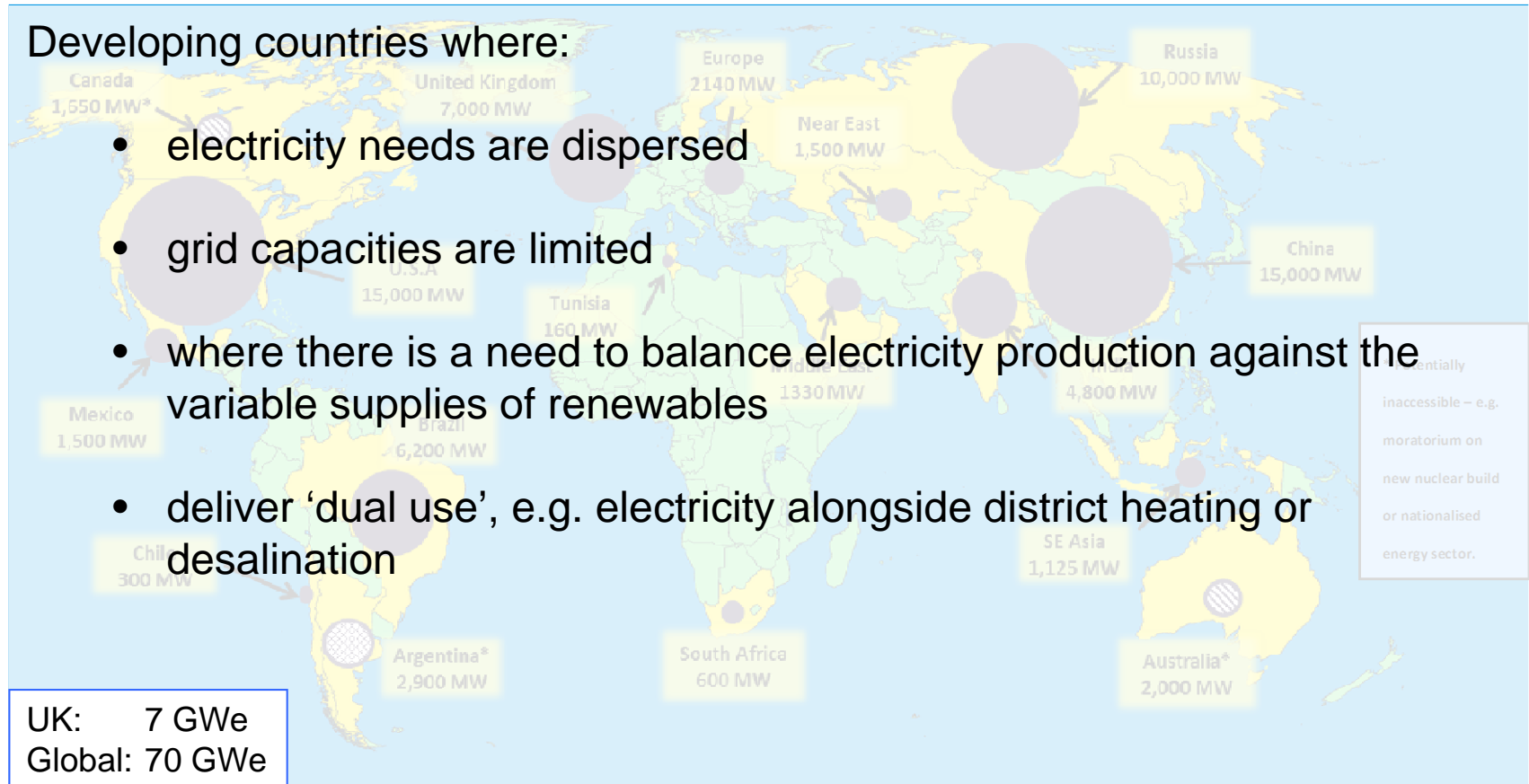


“Small Modular Reactors (SMR) Feasibility Study”, National Nuclear Laboratory, 2014

# SMRs in the UK – Why?

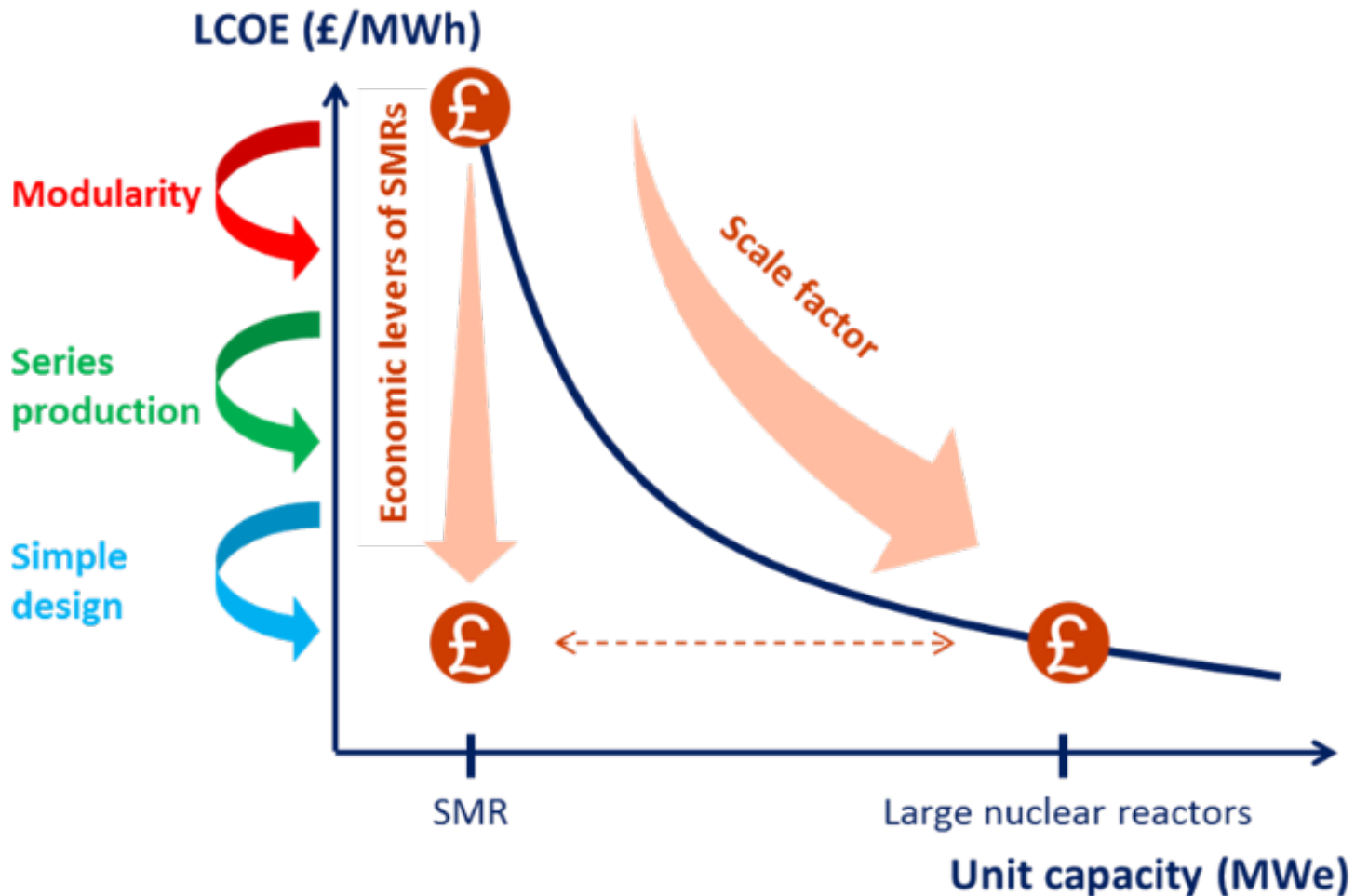
## Economic Driver

### Economic driver: international export opportunities



# SMRs in the UK – Why? Energy Driver

Energy driver: levelised cost of electricity

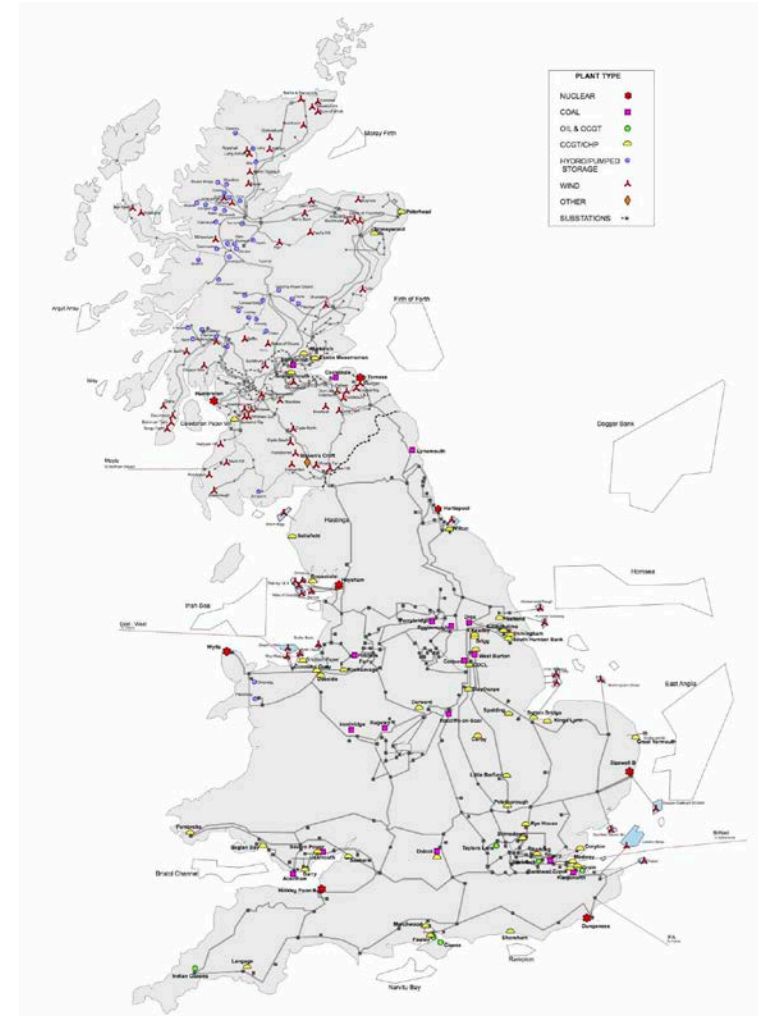




# SMRs in the UK – Why? Energy Driver

## Energy driver: fit within the UK energy network

- Siting assessment
  - 250 potential sites
  - Up to ~70GWe
- SMR application
  - Baseload power
  - Variable power (load follow)
  - Dual use (district heating)



- UK has experience across a variety of reactor systems and fuel cycles
- New Nuclear Power Plant construction programme underway (16GWe)
- New Nuclear Energy R&D Programme underway – need for more than 16GWe?
- Advanced systems being studied and specifically how SMRs could enable more energy production based on key economic and energy drivers.

# NATIONAL NUCLEAR LABORATORY

